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1961 Annual Report

U. S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE
Central States Forest Experiment Station, Columbus, Ohio

R. D. Lane, Director

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EXPERIMENT STATION

1961 Annual Report

U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

CENTRAL STATES FOREST EXPERIMENT STATION

R. D. LANE, DIRECTOR

111 OLD FEDERAL BUILDING, COLUMBUS, OHIO

CONTENTS

	<i>Page</i>
1961 Highlights	1
Forest Planting	3
<i>What is Plantable Land</i>	<i>4</i>
<i>How Productive is the Land</i>	<i>4</i>
<i>Species Selection Guides</i>	<i>6</i>
<i>Importance of Proper Seed Source</i>	<i>8</i>
<i>Direct Seeding</i>	<i>8</i>
<i>Importance of Planting Stock Quality</i>	<i>9</i>
<i>What Site Preparation is Necessary</i>	<i>9</i>
<i>Planting Methods</i>	<i>10</i>
Timber	11
<i>Hardwood Nursery Stock May be Lifted in the Spring or Fall . .</i>	<i>11</i>
<i>European Alder: A Promising Tree for Strip-Mine Planting . .</i>	<i>11</i>
<i>New Chemical Retards Height Growth of Black Locust</i>	<i>12</i>
<i>Seed Stratification Increases Seedling Yield of Yellow-Poplar .</i>	<i>13</i>
<i>Soil Micro-Organisms Increase Yellow-Poplar Seedling Growth</i>	<i>14</i>
<i>Direct Seeding of Shortleaf Pine</i>	<i>15</i>
<i>X-Rays for Detecting Viable Yellow-Poplar Seed</i>	<i>16</i>
<i>How Number of Defects Affects Grade of Hardwoods</i>	<i>17</i>
<i>Tolerance of Bottomland Hardwoods to Saturated Soils</i>	<i>17</i>
<i>An Easy Way to Calculate Crown-Surface Area</i>	<i>19</i>
<i>Killing Hardwood Culls</i>	<i>19</i>
<i>Woodland Management by Single-Tree Selection</i>	<i>19</i>
<i>Thinning Young Shortleaf Pine Stands</i>	<i>20</i>
Water	21
<i>Nuclear Soil-Moisture-Measuring Equipment</i>	<i>21</i>
<i>Temporary Weirs Can Be Made of Plywood</i>	<i>22</i>
Range	25
<i>Three Steps Improve Ozark Range</i>	<i>25</i>
<i>Effects of Fire in Rangeland Management</i>	<i>27</i>
Insects and Diseases	28
<i>A New Insect Pest of Scotch Pine</i>	<i>28</i>
<i>Tuliptree Scale Can Kill Yellow-Poplar</i>	<i>29</i>
<i>Borer Damage in 1-Year-Old Black Locust</i>	<i>30</i>
<i>Silvicultural Control for Red Oak Borer</i>	<i>30</i>
<i>Oak Wilt</i>	<i>31</i>

<i>Chlorotic Dwarf</i>	32
<i>Comandra Blister Rust</i>	34
<i>Fomes Annosus Root Rot</i>	34
Fire	35
Economics	36
<i>Timber Inventory in the Missouri Prairie Region</i>	36
<i>Veneer-Log Production Increases</i>	38
<i>More Cooperage Timber Harvested</i>	39
<i>Trends in Pulpwood Production and Consumption</i>	40
<i>Timber Buying and Selling by Ohio Sawmill Operators</i>	41
<i>Financial Returns Under Management</i>	42
Products	43
<i>Wood Bricks</i>	43
<i>Pallets</i>	45
<i>Oak and Hickory Picnic Tables</i>	46
<i>Log and Tree Grades</i>	46
1961 Publications	47

1961 HIGHLIGHTS

The first year of this new decade was a busy one at the Central States Station. We wound up some old business, progressed with current business, and began some new. This report is devoted chiefly to old business, however—a review of important research results that became available during the year. Some of the results discussed in the following pages were published in 1961, others will be released in the near future.

As a special feature, we are beginning our annual report with a summary of a forthcoming handbook covering progress in planting research in the Central States. Drawing upon the fruits of many years' experimental work in this field, this publication will bring together the best information available on planting practices, techniques, and recommendations for the Central States Region.

In addition to progress made this year on the Station's current research, our program continued to grow. Here are some of the highlights:

- The Mead Corporation of Chillicothe, Ohio, joined forces with the Station to begin research in the management of hardwood forests for pulpwood and other timber products. The corporation is contributing funds, technical assistance, labor, and other services and is developing an experimental forest in southern Ohio where the research will be concentrated. This work will be conducted from our Athens, Ohio, field office.
- With financial contributions from the American Walnut Manufacturers' Association and technical assistance from several state foresters, state agricultural experiment stations, national forests, and other public and private interests, we began black walnut tree improvement research. Our Bedford, Indiana, office is primarily responsible for this study.
- Hardwood bricks for construction will be produced and evaluated at our Carbondale, Illinois, field office in a new study supported by Private Enterprises, Incorporated, and Southern Illinois, Incorporated.
- The Ohio Power Company agreed to supply the Station with funds, land, and labor to conduct research on the biological control of the locust borer.

- We expanded greatly our cooperative-aid research with the state agricultural experiment stations and forestry schools in the Central States. Cooperative projects now are underway at the Indiana, Illinois, Iowa, Kentucky, Missouri, and Ohio Agricultural Experiment Stations and at Southern Illinois University. These studies cover a wide range of subjects in timber management, watershed management, economics, marketing, and utilization.

- We have undertaken at our Berea, Kentucky, field office research in acid-waste and stream-pollution problems associated with strip and auger mining in rough, forested watersheds. The Kentucky Department of Conservation has joined with us in this new work and, is contributing funds.

- Research was begun at Columbus, Ohio, on the opportunities for outdoor recreation on small, privately owned woodlands.

- New research aimed at expanding marketing opportunities for small-woodland owners was begun at our Carbondale, Illinois, field office.

- Research to improve systems and practices for processing and marketing timber products was begun at our Berea, Kentucky, field office.

- Research on hardwood and plantation insects, insect physiology, and vascular tree diseases, conducted at our Delaware, Ohio, laboratories, was strengthened.

- Soil-site evaluation for hardwood timber growth and range productivity research projects in progress at our Columbia, Missouri, field office were expanded.

- The interregional hardwood log and tree grade project conducted from Columbus, Ohio, was strengthened.

- And we expanded research at Columbus in the economics of growing hardwood timber in the Central States. Farm forestry opportunities are receiving emphasis in this project.

We are confident that the new work we started this year coupled with research we already had underway will yield large dividends. Our research will help provide the knowledge needed to protect, produce, utilize and market the multiple resources of forest land in the Central States.

RICHARD D. LANE
Director

FOREST PLANTING

During the past decade forest planting practices have changed greatly. The most notable advancement has been the shift to greater mechanization in site preparation as well as planting (fig. 1); the mattock and the plow are no longer the most common tools used in reforestation. Great strides have also been made toward better understanding of soil and other site factors influencing tree survival and growth. And the application of new findings in genetics, physiology, nursery practices, and ecology has helped in the selection and production of better stock for planting.

These new techniques and research findings have not been pulled together and made readily available to landowners who need them. So we are now preparing a handbook based mainly on these new findings. It is intended chiefly for extension specialists, state foresters, and others engaged in advising landowners in forest management. The handbook will provide the most up-to-date information available on where to plant, what to plant, and how to plant; publication is still several months away. This handbook, plus the one for planting on strip-mined land published a year ago, will serve as a complete guide to forest planting in the Central States.

The major points that will be discussed in the new handbook are summarized here.

Figure 1.—Most of the reforestation in the Central States today is done by machine.



What is Plantable Land?

The first thing to be done in establishing a new forest is to determine whether planting is needed, or whether the land will revert naturally to the type of forest wanted within a reasonable time. For open, nonstocked land, which includes prairie soils that never supported tree growth and forest soils previously cleared for farming, the decision is rather easily made: if the owner wants a forest cover within 5 years, planting will usually be necessary (fig. 2). But on partially stocked or cutover land, careful analysis is required to determine whether (1) present natural stocking is adequate, (2) the stocking that can be expected in the next 5 to 10 years will be made up of the species and density desired, or (3) planting will be necessary (fig. 3). Guidelines to help make this decision will be included in the handbook.

How Productive is the Land?

Before choosing the species to plant, the productivity of the land should be determined. Success or failure of the plantation will depend to a great degree on how suitable the land is for growing the species planted. Involved are such factors as soil properties and topography, kind and density of vegetation, and past land use.

Soil texture and structure, thickness of the topsoil, rooting depth, and drainage are now recognized as important factors to consider in predicting species response and tree growth. Site index (average heights of dominant trees at 50 years) of white pine (*Pinus strobus* L.) planted in southeastern Ohio, for example, varies from 39 feet on sites with 4 inches of topsoil to 57 feet on sites with 16 inches of topsoil.

The kind and density of vegetation already on an area to be planted influence the success of planting. A light overhead cover of oak (*Quercus* spp.) increases the chances for success in direct seeding shortleaf pine (*Pinus echinata* Mill.) in the Ozark uplands. On the other hand, a dense ground cover, such as horseweeds on a bottomland site, is a serious deterrent to successful planting, even though soil texture and drainage may be ideal.

Past land use — or abuse — has only recently been recognized as an important factor to be considered in choosing species for planting. The almost universal failure of hardwood plantings on typical old fields is no



Figure 2.—Most of our planting is on open, nonstocked land and brushy old fields not reverting naturally to desired species.



Figure 3.—More cutover and low-grade hardwood stands are being planted each year.

doubt related to past use. Some land cleared for agriculture once supported fine stands of hardwoods, but after years of deterioration brought about by erosion, gullying, and changes in soil structure it is more suitable for conifers than for hardwoods (fig. 4). We now have some evidence that the principal causes of hardwood failures on recently abandoned old fields, aside from topsoil losses by erosion, are deterioration in soil structure and the absence of soil micro-organisms. We also have some evidence that an old field at least partially stocked with trees is generally a better site for planting hardwoods than an old field with no tree cover.

Climate and physiography are also important factors governing the choice of species for planting. Recognizing this, separate sets of planting recommendations are being prepared for geographic areas differing significantly in length of growing season, rainfall pattern, and other climatic conditions. These will be subdivided into glaciated and unglaciated uplands, alluvial bottomlands, old lakebeds, and other easily recognized physiographic features.

Species Selection Guides

Separate "Species Selection Guides" for each state in the region will be featured in the handbook. A sample of these guides is given here (fig. 5). Species to plant are classified according to planting-site class and soil series.

Figure 4.—This land once supported hardwoods; it is now more suitable for pine. Clearing, cultivation, and erosion have resulted in topsoil losses, deterioration of soil structure, and reduction of beneficial soil micro-organisms.



SPECIES SELECTION GUIDE FOR FOREST PLANTING IN OHIO

A. RESIDUAL SOILS OF SOUTHERN AND SOUTHEASTERN OHIO

Planting Site Class	Soil Series	Species to Plant (in order of preference)	
		On open non-stocked land	On cutover or poorly stocked land
1. Severely eroded land; sheet erosion so severe that there is less than 3" of topsoil. May or may not be gullied.	All severely eroded soils.	Virginia pine Shortleaf pine ¹ / Loblolly pine ² / White pine	Loblolly pine ² / Virginia pine Shortleaf pine ¹ / White pine
2. Well-drained, medium-textured soils that occur on gently rolling to steep land; moderately permeable with little or no restriction to root development. a. Topsoil at least 7" thick, generally but not always on northerly and easterly slopes, coves, and lower slopes.	Derived chiefly from sandstone and shale: <u>Wellston</u> , Zanesville, Franktown, Tuscarawas, Gilpin, Muskingum, Meigs, Stony Muskingum, Stony Meigs, Tilsit Derived partly from limestone or other calcareous material: Brooke, Belmont, Westmoreland	White pine Loblolly pine ² / Shortleaf pine ¹ / Red pine ³ / Yellow-poplar Black walnut Black locust European larch	Difficult Planting Chance: Yellow-poplar N. red oak Black walnut White ash White pine Loblolly pine ² /
b. Topsoil 3" to 7" thick, generally on upper south and west slopes and dry, exposed ridges.		White pine Shortleaf pine ¹ / Loblolly pine ² / Red pine ³ / 	White pine Shortleaf pine ¹ / Loblolly pine ² / Red pine ³ /
3. Well-drained upland soils with moderate to slowly permeable clay subsoils. Rolling to steep land.	Rarden, Latham, Eifort, Upshur, Trappist, Coolville, Keene, Byington, Fawcett, Guernsey.	Shortleaf pine ¹ / Loblolly pine ² / White pine Red pine ³ / 	White pine Shortleaf pine ¹ / Loblolly pine ² / Red pine ³ /
See footnotes on last page.			

Figure 5.—Sample page of Species Selection Guide showing kind and organization of information presented.

Planting-site classes are differentiated mainly on differences in soil texture and permeability, rooting depth, and drainage. Most planting-site subclasses are based on thickness of the topsoil and aspect. The planting-site class and subclass describe important site conditions that should be evaluated before a choice of species is made.

The important soil series common to each planting site class are listed. This was done with the help of the Soil Conservation Service. For readers familiar with this soil classification, or if an up-to-date county soil map is available, the list of soil series will facilitate use of the planting guides. But because the planting subclasses are not readily identified by soil series, reference to the soil series is not a substitute for a field examination to determine these important site factors.

Species to plant are listed in order of preference for each planting site subclass; a separate list is made for open, nonstocked land and for cutover or poorly stocked land. "Difficult planting chance" means that although soil factors are favorable, tree planting will be difficult and costly because of the density of vegetation and the need for two or more release cuttings.

Importance of Proper Seed Source

The selection of seed for tree planting is as important as the selection of varieties of corn and strawberries for the garden. Seed source has an important bearing on the relative vigor, winter-hardiness, form, and resistance to drought, diseases, and insect pests. These characteristics are known to vary among different geographic origins and among stands of trees in the same locality. For example, loblolly pines (*Pinus taeda* L.) planted in Illinois from Maryland seed sources are much more winter-hardy than those from seed sources in Georgia. The sensitivity of yellow-poplar (*Liriodendron tulipifera* L.) (and other species) to late-spring frosts as related to seed origin is also now well known. Unless other seed sources have been proved superior, the selection of a local source is strongly advised.

Direct Seeding

Although direct seeding as a substitute for tree planting in the Central States is still rather risky business in most situations, we have scored notable successes in the direct seeding of shortleaf pine in the

Missouri Ozark uplands. Several studies and large-scale demonstrations have proved it feasible to convert low-grade hardwood stands on the ridges and upper slopes and to "sweeten" cutover land with shortleaf pine by direct seeding.

Importance of Planting Stock Quality

During the past two decades most publications on tree planting have stressed the importance of planting stock quality to assure good field survival. We still feel that stock quality cannot be over-emphasized. Various criteria for judging stock quality have been proposed. Good grading rules, however, must be simple and easily explained to laborers hired to do the grading. To meet this requirement, we have set up planting stock grades based only on size of stock and balance. For conifers, minimum stem diameter with top-length limits are specified. For example, shortleaf pine should have a stem diameter of no less than $5/32$ inch with a top 4 to 8 inches long. Hardwood grades are based mainly on stem diameter; for instance, $1/4$ inch is recommended for yellow-poplar.

What Site Preparation is Necessary?

Site preparation to control competing vegetation is often the most difficult (and costly) part of tree planting. On many open, nonstocked old fields no preparation is necessary; on some old fields and nearly all cut-over or poorly stocked land some form of site preparation is needed. Because of differences in costs and effectiveness, it is important to choose the right site preparation method. On open land with heavy sod, furrowing has in the past been necessary. Today the use of soil sterilants, such as Simazine, is effective on these sites (fig. 6). On brushy areas mechanical

Figure 6.—Soil sterilants, such as the Simazine used around this white pine seedling, appear promising as a control for heavy blue-grass sod in old-field plantings.



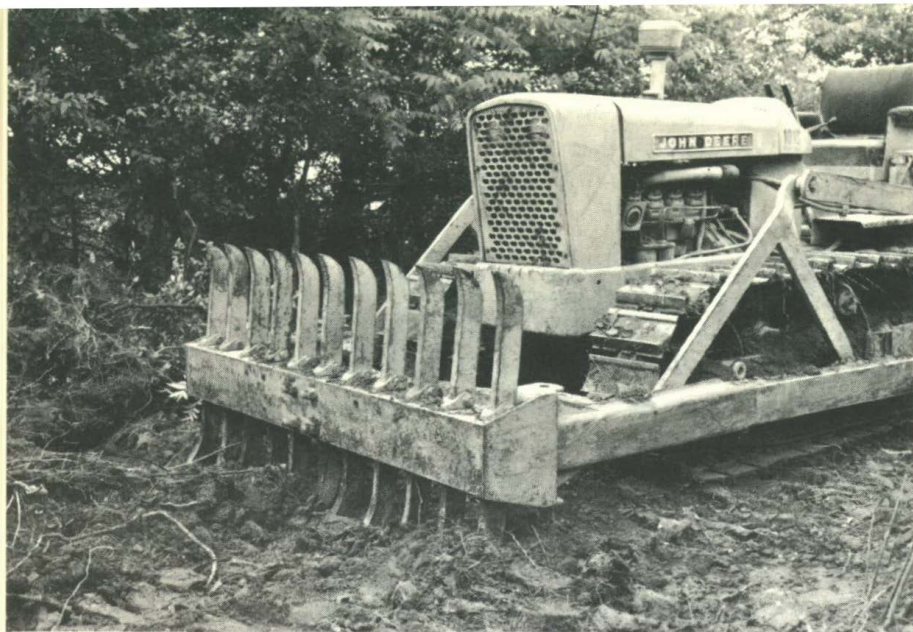


Figure 7.—The root-rake is an effective tool for clearing brushy areas before planting.

devices such as the root-rake may be used (fig. 7); or, depending on size of area, motorized or back-pack mist-blowers may be most effective in controlling vegetation. In low-grade hardwood stands and cutover areas, herbicides applied as aerial sprays or by mist-blowers have been satisfactory.

Planting Methods

Before 1945 nearly all of the tree planting in the United States was done by laborious, hand methods. Now, because of many technological advances and the scarcity and high cost of labor, most of the trees — perhaps more than 75 percent in the Central States — are planted by machine. With the advent of large-scale machine planting came doubts about the survival and growth of machine-planted trees. Results to date, however, show generally that both survival and growth of machine-planted trees are satisfactory. So today the choice between machine and hand methods of planting is governed largely by the size of the planting, topography, soil-moisture conditions, and the density and size of brush, trees, and debris. New, better, and more versatile machines are constantly being designed and tested with the result that the area plantable by machines is increasing.

New concepts in spacing and mixed planting have also been developed. Besides self-pruning and growth effects of spacing, other factors such as the effects of spacing on wood quality and the effects of early thinnings on the incidence of diseases and insect pests are now considered. New hazards in mixing pines and several species of hardwoods have also been demonstrated.

TIMBER

Our forest management research leads us down many pathways, but we have one major goal — attaining maximum productivity from our forest land. The Station's work on planting is featured earlier in the report. Briefly described here are some of our most recent research results in regeneration, tree improvement, silvics and silviculture.

Hardwood Nursery Stock May be Lifted in the Spring or Fall

We have found that hardwood stock lifted in the fall and heeled-in over winter will survive and grow just as well as spring-lifted stock.

In April 1960 and again in April 1961, fall- and spring-lifted red oak (*Quercus rubra* L.), black walnut (*Juglans nigra* L.), yellow-poplar, sweetgum (*Liquidambar styraciflua* L.), and sycamore (*Platanus occidentalis* L.) were planted on coal strip-mine banks in southern Indiana. Each spring, 500 fall-lifted and 500 spring-lifted seedlings were planted in paired rows.

So far no difference in survival (or growth) is apparent due to time of lifting. Mean second-year survival for the 1960 planting was 82 percent for the fall-lifted stock and 83 percent for the spring-lifted stock. For the 1961 planting, mean survival was 84 percent for the fall-lifted stock and 82 percent for the spring stock.

This research clearly shows that nurserymen in the Central States may lift hardwoods at their convenience after the plants have hardened off in the fall. Thus they may reduce soil compaction by keeping equipment off the beds when they are wet, provide jobs for key men over a longer period, and be ready to ship stock on short notice in the spring.

European Alder: A Promising Tree for Strip-Mine Planting

European alder (*Alnus glutinosa* (L.) Gaertn.) is widely used for reclamation planting in Europe, and after a 3-year trial it looks like a very



Figure 8.—European alder and shortleaf pine 3 years after planting on strip-mine spoil in eastern Kentucky.

promising tree for planting on strip-mine banks in the Midwest (25).¹ The alder seems particularly well suited to acid spoil, growing an average of 1 foot per year in Kentucky and Ohio on plots with a pH of 3.5. On less acid areas, the best trees grew 3 to 4 feet per year (fig. 8).

European alder is similar to black locust (*Robinia pseudoacacia* L.) in some respects and better in others. Both trees are nitrogen fixers and both survive and grow well on acid spoil. Alder, however, does not root-sprout, while locust root-sprouts prolifically, often spreading to crowd out interplanted trees. Moreover, alder does not seem to be plagued by serious insect pests as is the locust. Finally, alder has a narrower crown and better form than locust, hence produces less shade and potentially more commercial timber.

New Chemical Retards Height Growth of Black Locust

A new chemical, Phosfon-D, used by some florists to retard stem elongation and increase stem diameter, may be useful to tree nurserymen. Some hardwood seedlings become too large for convenient handling after only one growing season. The new chemical was tried on black locust, a fast-growing species.

In a pot study, black locust seed was sown in gallon cans containing 0.0, 2.5, 5.0, and 10.0 grams of Phosfon-D per cubic foot of potting soil. The chemical effectively retarded both height and stem diameter growth of black locust seedlings (fig. 9).

¹ Numbers in parentheses refer to publications beginning on page 47.

Figure 9.—Phosfon-D retarded the height growth of black locust seedlings.



In a companion nursery study, conducted at Indiana's Clark State Nursery, black locust seedlings were grown in concentrations of 0.0, 2.5, 5.0, 10.0 and 100.0 grams of Phosfon-D per cubic foot of soil. Nine weeks after sowing, differences in height growth among treatments showed that the growth-retardant chemical was indeed working. Three weeks later, however, the differences were disappearing, possibly because the Phosfon-D was leaching out. And at the end of the growing season there was little difference in height growth among treatments, although seedlings grown in the 100.0-gram treatment were more than 3 inches shorter than those grown in untreated soil.

If an effective way of using Phosfon-D in the nursery can be found it will give nurserymen another tool for controlling the size of some species. The chemical has not been effective on all plants so it should not be used indiscriminately until proved effective experimentally.

Seed Stratification Increases Seedling Yield of Yellow-Poplar

A recent study at the Vallonia Nursery in Indiana shows that more yellow-poplar seedlings are produced from a given quantity of seed as time of stratification is increased. In 1957 yellow-poplar seed was collected, weighed into lots of 5,000 seeds, and coated with a fungicide using a methocel sticker. Fresh seed was sown in the fall of 1957 and stratified seed was sown each spring after one, two, and three winters in stratification.

The percent of viable seed that produced seedlings ranged from 10 percent for the fresh seed sown in the fall of 1957 to 55 percent for stratified seed sown in the spring of 1960. The trend from poor to excellent yield as time in stratification increased indicates that prolonged stratification has a beneficial effect on seedling production.

Now seed collectors can safely take advantage of good seed years by collecting and storing high-quality seed from desirable yellow-poplar trees.

Soil Micro-Organisms Increase Yellow-Poplar Seedling Growth

Because of the possible significance of soil micro-organisms on a behavior of hardwoods planted on old fields, our exploratory studies in this field of research, reported in 1959, are continuing.

Pot-culture studies of seedlings grown in undisturbed soil cores taken from old fields have demonstrated that micro-organisms have a beneficial effect on the growth of yellow-poplar. Seedlings grown in soil sterilized with methyl bromide have grown poorly in the laboratory. Seedlings in unsterilized soil and in sterilized soil inoculated with either forest soil or macerated yellow-poplar roots grew vigorously (fig. 10). Seedling roots grown in the sterilized soil were essentially free of mycorrhizae. But the roots in unsterilized and sterilized-inoculated soil all contained heavy infections of fungal hyphae.

The first phase of this basic work is nearly complete and detailed results will be released soon. Further studies are needed to isolate and identify the particular fungus or fungi responsible for the formation of the mycorrhizae.

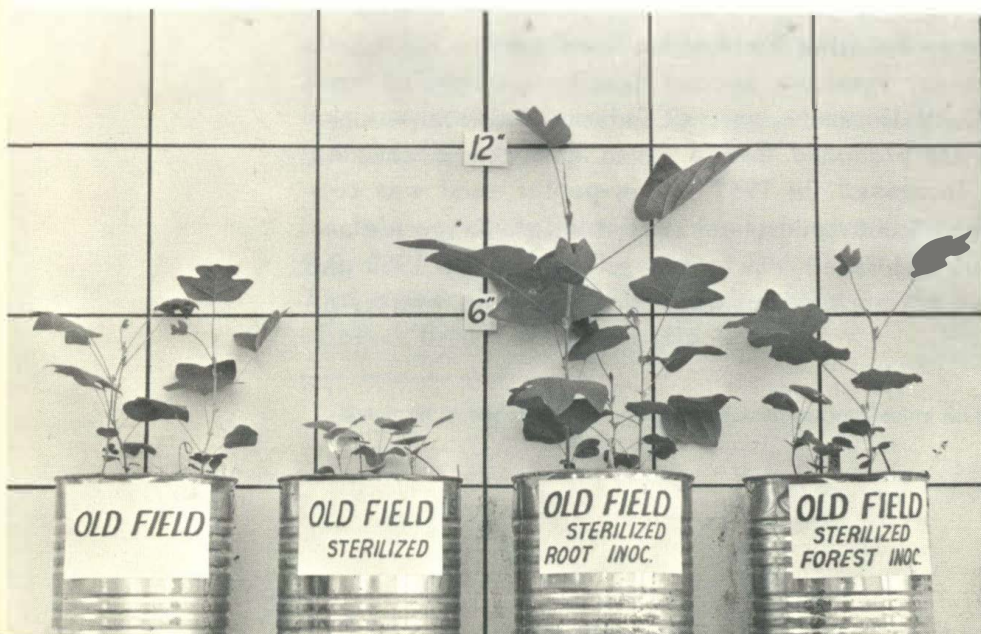


Figure 10.—Yellow-poplar seedlings grow poorly in sterilized soil; seedlings grow vigorously in sterilized soil inoculated with macerated roots or forest soil.

Direct Seeding of Shortleaf Pine

Our past studies have shown that low-grade oak stands in the Missouri Ozarks can be converted to the more valuable shortleaf pine by direct seeding. Now we know that the important factors affecting success are: (a) method of overstory removal, (b) month of seeding, (c) weather, and (d) litter cover (55) (56).

Results of our broadcast seeding this past year support the previous finding that December is the best time to sow seed. In broadcast seeding, litter cover appears to be the major deterrent to seedling establishment. So the best sites for seeding shortleaf pine are those that have mineral soil exposed, such as recently burned or cutover land.

Total costs of direct seeding range from 8 to 15 dollars per acre (table 1). In general, costs are roughly one-third to one-half the cost of planting comparable areas.

*Table 1.—Direct seeding costs, Clark National Forest, Missouri
(In dollars per acre)*

	Old field	Timberland			
		Clear cut	Heavy cut	Light cut	No cut
Seeding costs					
Seed	8.09	8.00	7.00	7.64	5.77
Repellents ^{1/}	.16	.16	.14	.16	.12
Sowing ^{2/}	.26	.37	.37	.64	.29
Other ^{2/}	.07	.25	.25	.54	.29
Subtotal	8.58	8.78	7.76	8.98	6.47
Release costs					
Chemicals ^{3/}			.34	.69	1.42
Labor			1.75	3.41	6.39
Other			.50	.41	.58
Subtotal			2.59	4.51	8.39
Total	8.58	8.78	10.35	13.49	14.86

^{1/} Anthraquinone, endrin, aluminum powder, and sticker.

^{2/} Treating seed, supervision, etc.

^{3/} 2,4,5-T in fuel oil.

X-Rays for Detecting Viable Yellow-Poplar Seed

Yellow-poplar samaras with filled seeds cannot be separated from samaras with empty seeds by the usual methods of screening—floatation, air currents, or visual examination—because the seed is formed as an integral part of the wing. Recently we developed a method for using a low "dosage" of x-rays for reliably identifying samaras with filled seeds (fig. 11). X-rays have previously been used to study the development of large tree seeds, but to our knowledge this is the first time they have been used to identify filled seeds within small-seeded, woody fruits. No visible effects on seed germination and on seedling growth from the x-rayed seeds have been detected.

Germination percentages of x-rayed samaras, extending over 3 years, are closely correlated with the percentage of filled seeds of dissected samaras from the same trees. Seedlings from x-rayed seed did not show aberrant forms and they grow as well as non-x-rayed seedlings.

Low dosages of soft x-rays offer a reliable research method for identifying samaras with filled seeds but it is too expensive for nurseries. Percentage of filled seeds can be determined rapidly without destroying the seeds by cutting into them and without having to wait 3 years for the results of a germination test.

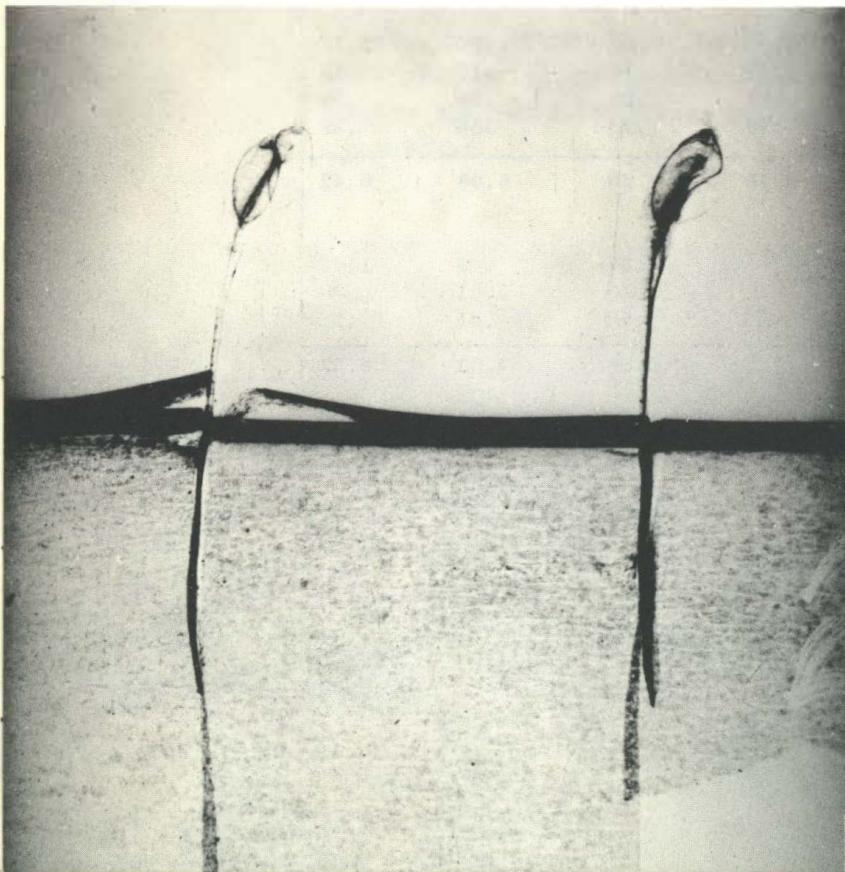


Figure 11.—X-ray photograph of two samaras showing an upper filled seed and a lower empty seed in the left samara. The samara on the right has two empty seeds. The elliptic-shaped dark lines represent the seedcoat and the long lines represent vascular tissue.

How Number of Defects Affects Grade of Hardwoods

The quality of hardwood logs can be improved by growing trees that inherently develop fewer defects and by various silvicultural practices such as pruning. In our tree-improvement work we need a way to evaluate this change in tree quality. For example, if a strain of tree develops half the usual number of defects, how does this change the relative quality in terms of number of grade 1, 2, and 3 logs these trees will yield? To what extent must we reduce the number of grading defects so that 70, 80, or 90 percent of the butt logs will qualify for grade 1? And in selecting superior trees, what is the maximum number of inherent grading defects that can be permitted?

Our approach to the problem is based upon the probability of the butt log qualifying as factory log grade 1, 2, or 3 when different numbers of defects are present. Over 1,100 logs (black oak (*Quercus velutina* Lam.), white oak (*Q. alba* L.), northern red oak, scarlet oak (*Q. coccinea* Muenchh.), and yellow-poplar) were carefully diagramed and graded using the Forest Products Laboratory rules. We segregated the logs into the three log grades on the basis of defects indicated by surface characteristics only; our sample did not include logs degraded because of small diameter, fire scars, sweep, crook, and interior cull. We determined the number of defects for each log, then plotted the percentages of grade 1, 2, and 3 logs over the number of defects.

Our method does not grade or evaluate individual logs or trees and, therefore, is not a substitute for log- and tree-grade systems. It is useful in evaluating relative gains in tree quality resulting from the introduction of inherently improved trees. For example, for butt logs having ten defects, 17.9 percent are expected to qualify for grade 1, 81.0 percent for grade 2, and 1.1 percent for grade 3 (fig. 12). Two generalizations can be drawn: (1) the greatest gains in log quality and in monetary value are made by reducing the number of defects in the butt log from eight to four; (2) trees with four or less defects in the lower 16-foot log with a top diameter of 13 inches or more may be of a superior strain so selection and breeding programs should strive to develop races of trees that produce four or less defects in the butt log.

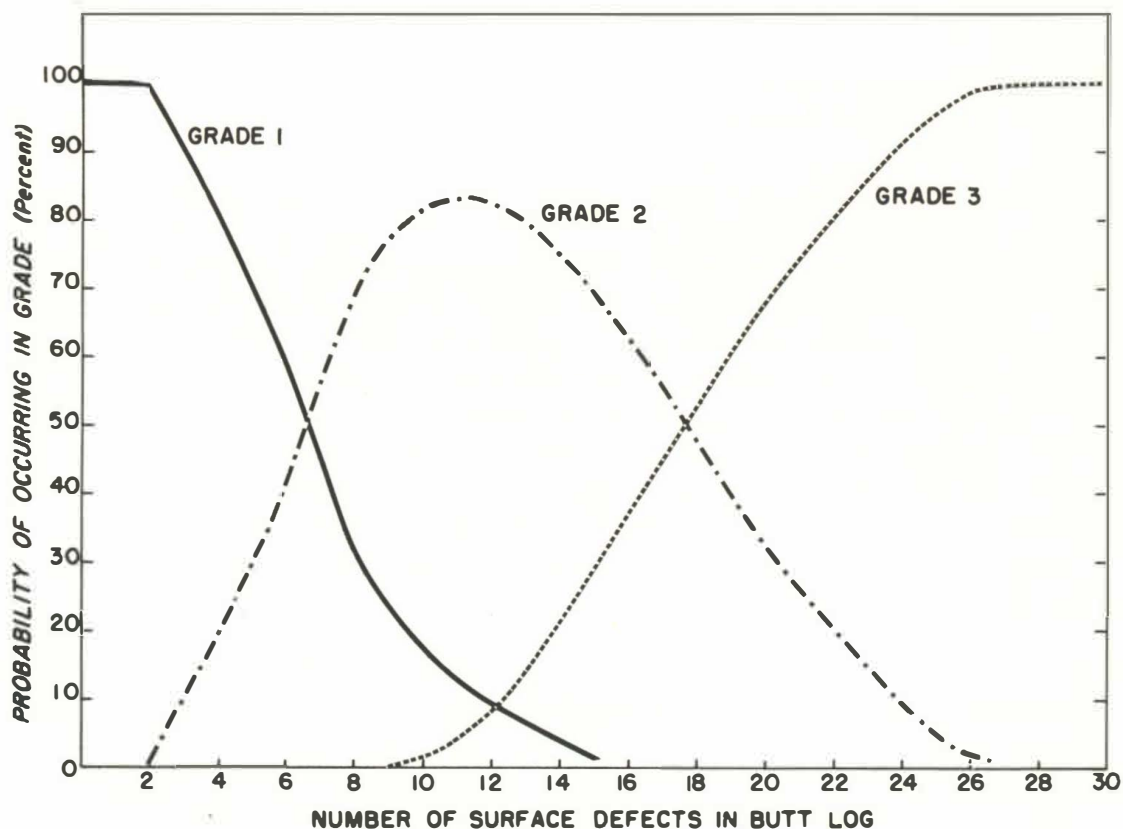
Tolerance of Bottomland Hardwoods to Saturated Soils

The ability of different tree species to survive and grow in saturated soils is important in the regeneration and succession of bottomland tim-

ber. In a cooperative study with Southern Illinois University, we tried to find out the relative ability of seedlings of 17 species to survive and grow in soils saturated for periods of 15, 30, and 60 days. First we grew the seedlings in large tanks of soil, then we flooded them with water to a depth of about 1 inch over the soil.

Very few seedlings died; however, the degree to which species were affected varied. Seedlings of tupelo (*Nyssa* spp.), willow (*Salix* spp.), green ash (*Fraxinus pennsylvanica* Marsh.), and pumpkin ash (*F. profunda* (Bush) Bush) continued to extend their root systems during long periods of complete soil saturation. Other species (cottonwood (*Populus* spp.), willow, sycamore, silver maple (*Acer saccharinum* L.), and red maple (*A. rubrum* L.) rapidly put out new adventitious root systems, replacing those functioning poorly or not at all. Evidently once seedlings of all the species we used are established, flooding of the soil will not do a great deal of harm.

Figure 12.—Probable grade distribution of butt logs by number of defects.



An Easy Way to Calculate Crown-Surface Area

Crown-surface area is often closely correlated with tree size and growth rate, and hence is a useful measurement in studies of tree growth. Solving standard equations to get estimates of surface area, however, may be a rather difficult and time-consuming task. We can calculate the square feet of crown-surface easily if we first determine the crown-length/crown-diameter ratio and then multiply crown diameter (in feet) by crown length (in feet) by the proper adjustment factor.

The adjustment factors we have developed for Central States hardwoods having crowns resembling cones or paraboloids are given below:

Crown-length/ crown-diameter ratio	Adjustment factor	
	Cone	Paraboloid
0.5	2.222	2.665
1.0	1.756	2.260
1.5	1.656	2.171
2.0	1.620	2.140
2.5	1.603	2.124
3.0	1.593	2.113

Killing Hardwood Culls

We have experimented with several methods of killing hardwood culls at the Kaskaskia Experimental Forest (46). On the basis of diameter inches treated, the injector method was the cheapest and the low ax frill the most expensive. However, based on diameter inches of trees killed, the low ax frill method was relatively cheap. Where 100 percent top and root kill is desired and where immediate silvicultural benefits are important, we recommend the low ax frill with 2,4,5-T. This method is especially advantageous to owners of small woodlands with few trees to kill because of the relatively low cost, simple equipment needed, and the ease of doing the job (fig. 13).

Woodland Management by Single-Tree Selection

After 9 years of experience we know that the single-tree-selection method using a 3-year cutting cycle cannot be sustained indefinitely in



Figure 13.—Applying 2,4, 5-T solution to a low ax frill.

uneven-aged, upland hardwood timber in southern Illinois (50). Our experimental cutting has removed nearly all the economically mature trees, and has not favored the establishment of desirable reproduction. Further, the method has stretched the rehabilitation job over a long period and the light, frequent cuts have less appeal for a commercial operator.

How should stands of this type be cut in the future? We favor a group-selection cutting made less frequently, producing more operable volume. The openings created would favor reproduction, and if necessary we would release desirable species from competing vegetation.

Thinning Young Shortleaf Pine Stands

Thinning well-stocked shortleaf pine stands in southern Illinois may be delayed to ages 17 to 20 years on poor sites or 22 to 25 years on good sites. We found no advantage in either yield or value return from earlier thinnings made at ages 15 to 17 years.

Not only the timing of the first thinning but also the residual density after thinning should be related to site quality. Our research results suggest that the first thinning reduce basal area to 70 to 80 square feet on poor sites, 80 to 90 on medium sites, and 90 to 100 on good sites.

WATER

Water is constantly moving. It moves through the air, over the earth's surface, and beneath its surface. Some movements are essential to life; others may be destructive. Some water movements are large, spectacular and awesome; others are minute, obscure, and subtle. Water movements through the soil, although complex and difficult to measure, are important in explaining the effects of plant cover type and land management practices on evapotranspiration losses and water available for streamflow. In watershed management research we are attempting to measure, relate, and predict some of the soil-water movements.

Nuclear Soil-Moisture-Measuring Equipment

We are using nuclear radiation equipment to help facilitate soil-moisture and bulk-density measurements required in our soil-water-movement research (fig. 14). Advantages of this equipment are:

- (1) It is rapid. Once a station has been selected and prepared, a reading of moisture or bulk density can be made in 2 or 3 minutes.
- (2) It is reliable. Inherent variability of the equipment usually amounts to less than 2 percent of the total reading.

Figure 14.—Measuring soil moisture with a radioactive, subsurface-moisture meter. Note the film badge on the operator's left trouser leg. This is a safety device for monitoring the amount of radiation the operator receives while operating the meter.



(3) It is portable. Two men can carry the entire set.

(4) Repeated measurements can be made at the same site, since the sampling point is not destroyed.

(5) It works well on sloping, stony soils where conventional methods are difficult or impossible.

Much that we have learned about this equipment will serve to guide future uses that we and others make of it:

(1) Single, 1-minute readings are adequate for subsurface moisture determinations.

(2) The manufacturer's calibration curve for each probe must be checked. This may require relatively few samples (fig. 15).

(3) The surface-moisture meter will probe through a thicker layer of dry soil than wet soil. For example, at 40-percent soil moisture (by volume) the soil thickness probed was 7 inches, while with 10-percent moisture the thickness was 10 inches (fig. 16).

(4) When a surface-moisture probe is used on a shallow soil, the depth from surface to bedrock must be known. If less than 8 inches it may be necessary to run a separate calibration for that particular soil.

(5) The surface-moisture probe must be used on a smooth surface because its counting rate decreases as air space between meter and soil surface increases. We found that pine needles exert the same influence as air space, hence it is impractical to make readings with the meter placed loosely on top of the forest floor. Changes in litter accumulation, organic matter decomposition, and moisture content of the litter between reading dates may cause false readings.

(6) Type of access tubing affects both subsurface density and subsurface moisture readings.

Temporary Weirs can be Made of Plywood

Plywood can be used successfully for temporary cutoff walls in small watersheds where physical damage from sediment and debris is not a problem (fig. 17). Such weirs have served well for 2 years on two 20-acre

Figure 15.—Surface-moisture calibration curves, June 1961.

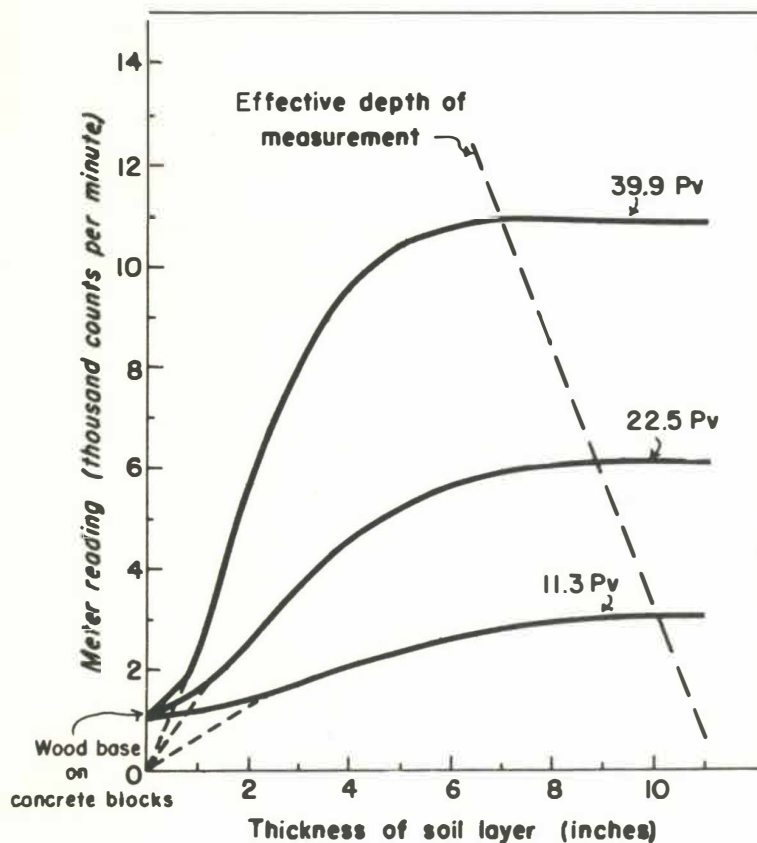
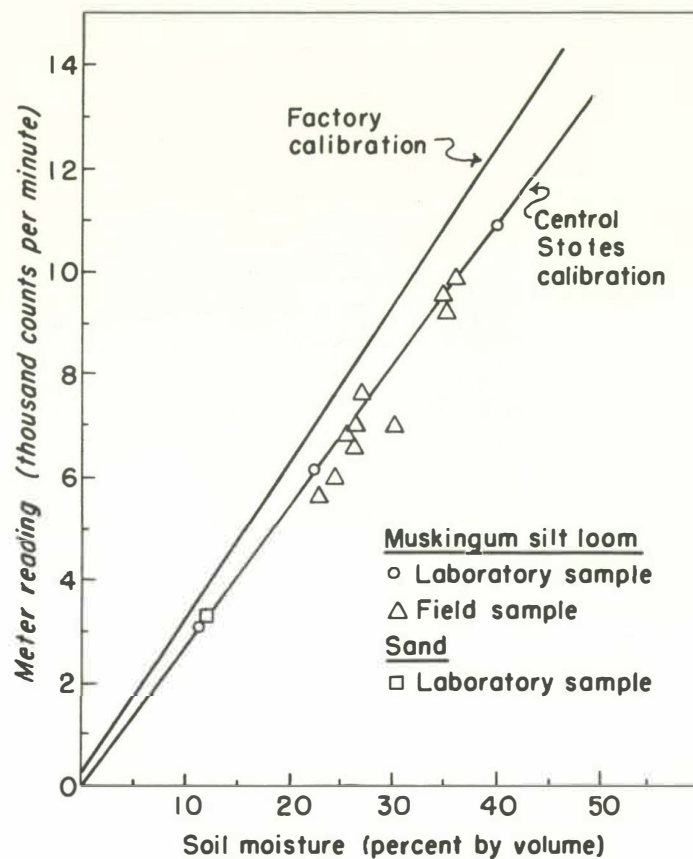


Figure 16.—Relation of Muskingum silt loam soil thickness to surface-moisture-meter reading, June 1961, at three Pv (soil-moisture percent by volume) levels.



Figure 17.—Plywood cutoff wall for a temporary weir.

watersheds, located in a well-protected hardwood forest in the Muskingum Conservancy District (63). A 90-degree, sharp-crested blade on the plywood wall assures sensitive, low-flow measurements. There seems to be little difference between the friction coefficient of our plywood cutoff wall and that of the material used in deriving the original weir equation.

RANGE

Livestock production is one of the leading industries in the Ozark Region. But often the forage resource, upon which this industry depends, is damaged and depleted by overgrazing. Restoring forage production then becomes necessary. We have found we can do it through good conservation practices and by reseeding, fertilizing, and converting areas with low capacity for timber production to productive range.

Three Steps Improve Ozark Range

Three steps needed to increase forage production on forest rangeland in the Ozarks are: (1) spraying with herbicides, (2) seeding adapted forage species (after a prescribed seedbed preparation of summer burning), and (3) applying commercial fertilizer (61). In our experiments these steps increased the total yield sharply and at the same time yielded better quality forage (fig. 18).

Aerial spraying forest rangeland with 2,4,5-T, without any other improvements, increases total forage production. However, in this case, the forage produced depends upon the type of seed source present at the time of release (fig. 19). Where overgrazing has reduced desirable forage species, the bulk of the increase will be in weedy plants. In such situations forage quality can be improved by seeding with introduced or native species.

In one experiment we increased forage production from less than 50 pounds per acre to more than 400 pounds 1 year after aerial spraying hardwoods with 2,4,5-T. Commercial fertilizer (320 pounds per acre of 8-24-8) or seedbed preparation (a prescribed summer burn after spraying) further increased herbage production to about 1,000 pounds per acre. Both treatments combined increased forage to over a ton per acre.

These treatments were further augmented by seeding a mixture of either K-31 fescue (*Festuca arundinacea* Schreb), Korean lespedeza (*Lespedeza stipulacea* Maxim.), and sericea lespedeza (*L. cuneata* Dum.-Cours.-G.-Don.), or native grasses such as little bluestem (*Andropogon*



Figure 18.—This area was aerial sprayed with 2, 4, 5-T in July 1959, burned in August to prepare the seedbed, seeded to K-31 fescue-lespedeza mixture in September, and fertilized. The average yield in 1960 from areas treated in this manner was about 2,300 pounds per acre (oven-dry).

Figure 19.—This is typical of the good native herbage that can be produced on Ozark forest ranges. If the ranges have not been abused in the past and if a good seed source of desirable forage plants is present, they can produce as much as 3,000 pounds per acre (oven-dry) within a few years after spraying with 2, 4, 5-T.



scoparius Michx.), big bluestem (*A. gerardi* Vitm.), Indian grass (*Sorghastrum nutans* (L.) Nash.), switchgrass (*Panicum virgatum* L.), and sideoats grama (*Boutelous curtipendula* Michx.-Torr.). All areas seeded to the fescue-lespedeza mixture produced from 10 to 200 percent more forage than similarly treated areas that were not seeded. Seeding of the native grass mixture did not give a consistent increase in total forage production the first year because native grasses become established more slowly than fescue. In another year or so these areas should have an increase in yield.

Of course, the big difference between seeding and not seeding is in the much greater amount of good-quality forage on the seeded areas. For example, on the sprayed and fertilized areas that were seeded, nearly 72 percent (over 1,000 pounds per acre) of the total yield was high-quality forage; whereas on areas not seeded only 8 percent (85 pounds per acre) was high-quality forage.

Effects of Fire in Rangeland Management

The effects of fire on range vegetation is a controversial subject in the Ozarks because the effects, often drastic and obvious, can be beneficial or detrimental depending upon many factors and conditions. We have been cooperating with the University of Missouri in a study begun in 1958 to learn more about the effects of burning upon the ecology of Ozark prairie vegetation.

After four annual spring burns, made under controlled conditions, forage increases averaged 200 percent more than on nonburned areas. Increased production is due to more foliage and flower stalks for certain perennial grasses. Also growth began 7 to 10 days earlier on burned areas. Accumulation of mulch on nonburned prairies tends to arrest seasonal development of the prairie grasses, causing stagnation in a few years. We have not detected any significant physical changes in the root zone due to annual burning. We still must determine if controlled burning is beneficial or harmful to soil, water and range resources under other common range conditions.

INSECTS and DISEASES

Our research in forest insects and diseases is designed to develop new and better ways to prevent and control forest pest outbreaks in the Central States. Before we can make significant strides toward this goal, however, we need to know more about the behavior of the offending organisms themselves. So we are concentrating our research on the life history, habits, population dynamics, and ecology of insect and disease pests common to Central States forests.

A New Insect Pest of Scotch Pine

The new bud miner, found in buds of Scotch pine (*Pinus sylvestris* L.) in Lake County, Ohio, in 1960, has been observed in several adjacent counties since then. Specimens of this insect were sent to the National Museum in 1960 and were classed as an unknown species of the genus *Exoteleia*. Dr. T. M. Freeman, Entomologist, Canada Department of Agriculture, recognized this miner as a new species first observed in Canada a few years ago. The early stages of the larvae are spent in the needles (fig. 20), but during the later stages in May or June the larvae move into the buds. We are attempting to collect all stages of this insect to aid in determining the species.

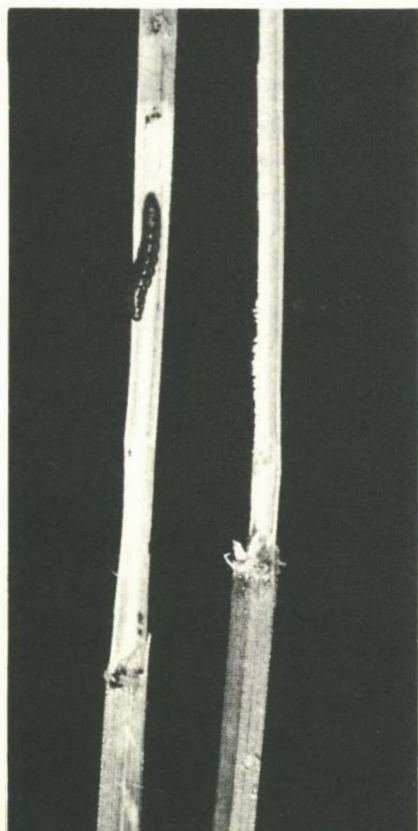


Figure 20.—Pine needles cut open to disclose the young larvae of the pine bud miner.

Tuliptree Scale Can Kill Yellow-Poplar

Insects such as the bark beetles and sawflies that cause catastrophic damage to timber stands are well known to foresters and land managers. But the damage done by some of our more insidious sap-sucking insects has generally escaped notice. One such insect is the tuliptree scale (*Toumeyella liriodendri* (Gmel.)) (fig. 21). This scale was found in all the yellow-poplar stands we visited in widely scattered points in Kentucky and Ohio. In 1959, we began studying this insect and the damage it caused to yellow-poplar reseeding naturally in an old field in Ohio (23). The trees were heavily infested with scale. The average number of poplar trees had dropped from 90 to 75 per acre and every dead tree had been infested with scale. Dead trees ranged from seedlings less than 1 inch in diameter to saplings 5 inches in diameter. Among the larger trees, 4 to 6 inches in diameter, a permanent crook develops when the insect repeatedly kills the terminal shoot (fig. 22).

So far we have found a number of insect parasites and predators as well as one disease that helps reduce the scale population. More research on these natural enemies of the scale may lead to effective biological controls.



Figure 21.—(above) Adult female scale with beads of honeydew.

Figure 22.—(below) Crook may result when the terminal shoot is killed by the tuliptree scale.





Figure 23.—Borer damage in black locust planted as year-old stock in spring of the previous year.

Borer Damage in 1-Year-Old Black Locust

Past reports have indicated that damage by the black locust borer (*Megacyllene robiniae* (Forster)) has been confined to sapling-size trees or larger. However, in a series of five plots established in April 1960 with 1-0 stock we found that by fall of the same year 8 percent of the new locust trees had been attacked (fig. 23). Even trees in plots isolated from older stands were damaged. In a reclamation planting made the same year, 10 percent of the new seedlings were attacked.

Silvicultural Control for Red Oak Borer

The red oak borer (*Romaleum rufulum* (Hald.)) degrades large amounts of oak timber by boring into living trees (fig. 24). It is the larvae of the insect that does the damage. So, we wanted to find out if killing the host tree would also kill the larvae and thus, give us a control.

These insects have a 2-year life cycle, and their first year the larvae do not penetrate much beyond the bark. We found that if the larvae had not actually entered the wood when the tree was killed they could (or would) not develop further. If they had already penetrated into the wood they could continue to develop and become adults.

This finding has an immediate practical application in timber-stand-improvement work in areas infested with the red oak borer. Future population of the borer can be reduced if the low-quality trees in the stand,

Figure 24.—Red oak borer tunnels and associated stain in black oak.



which also are the ones most likely to be heavily infested, are killed between July 1 of the odd-numbered years and June 1 of the even-numbered years.

Oak Wilt

Several countries have embargoes against oak logs and lumber from the United States unless such material is certified as disease-free by the U. S. Department of Agriculture. This certification is currently being provided only for oak products originating outside the known range of the oak wilt disease (*Ceratocystis fagacearum* (Bretz) Hunt) or for oak products that have been kiln-dried to a moisture content of 20 percent or less.

The known range of oak wilt includes much of the commercial oak-producing area of this country. Kiln-drying is impractical for the large-dimension and veneer stock that comprises much of our exported oak. Therefore, we are trying to devise a treatment that is completely effective for killing the fungus in such products, has no undesirable side effects, and is economically feasible.

In laboratory tests, wilt-infected oak bolts, 4 inches in diameter and 8 inches long with the bark intact, have been sterilized by exposure to saturated atmospheres of methyl bromide or chloropicrin at room temperature and atmospheric pressure for 3 days (53). We are now experimentally applying these findings to commercial-size oak logs.

Oak logs cut from wilt-infected trees were treated with methyl bromide under a plastic tarpaulin (fig. 25). Some of the logs were peeled before treatment and some were treated with the bark intact. Early results of this research are encouraging, but more refined studies scheduled for next year must be completed before this treatment can be fully evaluated.

Chlorotic Dwarf

The primary cause of the chlorotic dwarf disease of young eastern white pines is not yet known. Although research has been in progress for several years, we still do not know whether the disease results from an attack on the foliage or on the root system. Since diseased trees characteristically shed some of their needles prematurely, we thought perhaps there was some relation between needle retention and the development of disease symptoms. Thus, in 1960, needles of different ages were removed from a number of healthy, 5-year-old white pines in an Ohio plantation. Treatments consisted of removing (1) all current needles, (2) all needles except current, (3) all needles, and (4) no needles. This was done first in July 1960, repeated in September 1960, and again in April 1961.

Complete defoliation in April and July and removal of current needles in April killed the trees. But complete defoliation in September and the removal of current needles in July and September resulted in symptoms closely resembling chlorotic dwarf during the growing season of 1961 (fig. 26). Removing all needles except for current foliage reduced growth, but did not induce typical disease symptoms. These results suggest that chlorotic dwarf may in some way be associated with needle retention.

Symptoms of chlorotic dwarf are similar in some respects to those commonly associated with malnutrition. Research was started in 1958 and 1959 to evaluate the effects of applying fertilizer, lime, and organic chelates on diseased trees. Results were measured in terms of increased shoot growth on approximately 300 pines in a 5-year-old plantation. Two spring applications of 10-6-4 fertilizer, lime, or both, resulted in partial recovery of the trees. However, chelated calcium, copper, iron, magnesium, manganese, or zinc, when sprayed either on the soil or on the foliage, failed to produce a significant response. Further research is in progress to determine if successive applications of fertilizers over a period of several years will promote complete recovery.

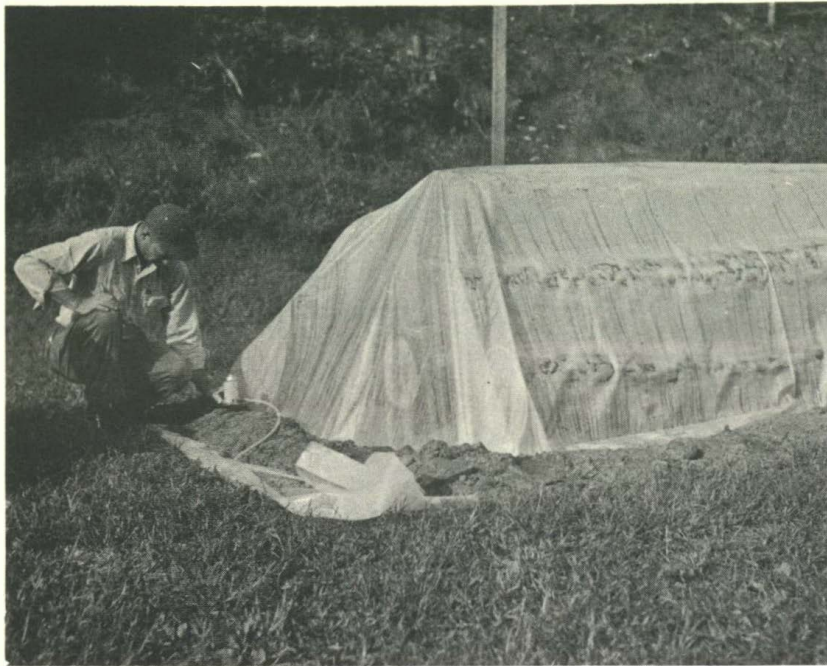


Figure 25.—Methyl bromide is applied to wilt-infected oak logs beneath a plastic tarpaulin.



Figure 26.—This 5-year-old eastern white pine, completely defoliated in September, shows chlorotic dwarf symptoms the following year.

Comandra Blister Rust

In the spring of 1961 comandra rust (*Cronartium comandrae* Peck) was discovered in a 6-year-old shortleaf pine plantation in Dent County, Missouri (3). A number of pine seedlings throughout the 5-acre plantation were either infected or had been killed by the rust fungus. Although comandra rust has been previously reported on hard pines in both eastern and western United States, this was the first time it had been found on shortleaf pine.

Fomes Annosus Root Rot

During 1961 a survey was made to obtain information on the occurrence and severity of *F. annosus* (Fr.) Cke. in natural and planted stands of shortleaf pine in Missouri. *F. annosus* infection centers were found in 80 percent of the thinned pine plantations and 58 percent of the thinned natural pine areas that were examined. No evidence of *F. annosus* was found in plantations or natural areas in which there had been no cutting.

Generally, infection centers ranged in size from a few to a dozen or more dead and dying trees. However, in one 26-year-old plantation, approximately 75 percent of the trees in the southern half of the plantation were either infected with *F. annosus* or apparently had been killed by the disease. In natural pine stands there was less apparent damage from the fungus than in plantations.

Figure 27.—(right) The Model II Michigan Sand Caster, shown at work, is towed by a tractor. All other power needs are supplied by its own 130-hp. engine. A 36-inch rotor drives soil from the ground over which the machine travels leaving a clean trench about 2 feet wide and 6 inches deep. (Photograph courtesy of Michigan Department of Conservation.)

FIRE

A new type of fire-control machine — the Model II Michigan Sand Caster — is being developed and tested (fig. 27). This has been a cooperative research and development venture with the States of Michigan, Georgia, and Florida, Forest Service Regions 8 and 9, and the Southeastern and Central States Forest Experiment Stations participating.

Use of soil in fire control is not new: we have long used hand shovels to move small quantities of soil and fire plows and bulldozers to build soil barriers. This new machine, however, was designed to actually cast a large volume of sand on flames or on fuels to prepare fire-retarding strips. Maximum capacity of the machine is about 4 cubic yards per minute at a speed of 1.5 m.p.h., or about 2.8 cubic yards per 100 feet of line when making a 6-inch-deep trench. Sand is cast about 50 feet.

Experience has shown that 2 to 3 cubic yards of soil per 100 feet of line is effective in extinguishing flames and reducing possibility of fires igniting and spreading in treated fuels. Effective control, of course, depends a great deal upon character of fuel, intensity of fire, and soil-moisture content.

The sand caster performs well in sandy soils, but is not practical in heavy or rocky soils. The rotor has a tendency to clog in heavy surface fuels or logging debris. These along with solid objects, such as heavy roots or stumps, may break the shock load shear pin.

So far, the machine lacks the dependability to be widely used but its potential justifies further efforts in development.



ECONOMICS

In 1961 our research in forest economics provided new information on: (1) the forest resources in western Missouri; (2) the production of veneer, cooperage, and pulpwood; (3) the purchasing and sales activities of Ohio sawmill operators; and (4) net returns obtainable from Missouri Ozark timber when it is under management.

Timber Inventory in the Missouri Prairie Region

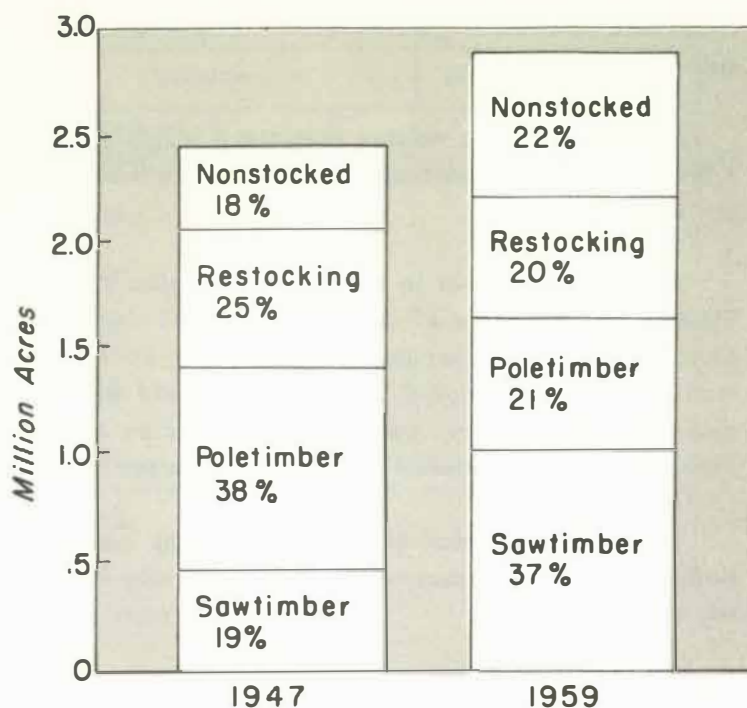
The new Missouri forest survey shows that the Prairie Region (comprising 44 percent of Missouri's total land area) is the least forested region in the State (fig. 28).

Only 2.9 million acres or 15 percent of the land area of the Region is in forest. The forest is generally limited to the wet bottoms and rough hills along streams and to small scattered farm woodlots. About 99 percent of the commercial forest area is privately owned and more than three-fourths of the owners are farmers.



Figure 28.—The Missouri Prairie Region.

Figure 29.—Distribution of commercial forest area by stand-size class, 1947 and 1959.



Since the last timber inventory in 1947, the forest acreage of the Prairie Region has increased about 15 percent. A large part of this increase is land now in the Conservation Reserve under the Soil Bank Act of 1956. Much of this land is restocking naturally to timber. When the Reserve contracts terminate, however, this land is expected to return to nonforest uses.

Elm-ash-cottonwood is the predominant forest type in the Prairie Region. It occupies 1,359,000 acres or 48 percent of the total commercial forest acreage. Black-scarlet oak, occupying 852,000 acres, is the second most extensive type.

Four and nine-tenths million cords or 44 percent of the Prairie growing-stock volume is oak and 2 million cords or 18 percent is elm, a species with limited markets. One-third of the oak volume is white oak.

Since the 1947 survey, sawtimber stands have more than doubled in area and now occupy 1,041,000 acres or 37 percent of the commercial forest (fig. 29).

Total growing-stock volume increased 18 percent to 10.9 million cords and sawtimber growing-stock volume increased 14 percent to 3,059 million board feet.

Average per-acre volume increased slightly from 3.7 cords in 1947 to 3.9 cords in 1959. Sawtimber volume now averages about 1,080 board feet per acre.

Annual net growth in the Prairie Region amounted to 610,000 cords. This is equivalent to 17 cubic feet or 0.22 cords per acre. Forty-five percent of this growth occurred in pole-size trees. Annual sawtimber growth was 171.1 million board feet or 60.5 board feet per acre. Two-thirds of this growth, however, was accounted for by trees just reaching sawlog size. In sawtimber stands the rate of increase was 99 board feet per acre.

Under good forest practices 395,000 cords, including 117 million board feet of sawtimber, can be cut annually from the Prairie forest during the next decade.

Veneer-Log Production Increases

Our biennial canvass of veneer-log production and consumption disclosed that production in 1960 was more than 59 million board feet, an increase of 12 percent over that of 1958 (table 2). Consumption of veneer logs also increased almost 11 percent, amounting to 59.7 million board feet.

Indiana forests yielded more veneer logs than any other single state in the region. Black walnut was the principal species harvested. Some 18.5 million board feet of black walnut veneer logs were cut in 1960, an increase of almost 22 percent over that of 1958. Cottonwood ranked second in the volume produced, accounting for almost 12 million board feet.

A total of 51 veneer mills in the Central States consumed 59.7 million board feet of logs. Approximately 60 percent of the veneer logs were manufactured into high-quality face veneer. The remaining 40 percent were used to produce container veneer.

Mills in Indiana manufactured most of the veneer in the Central States. Black walnut and cottonwood were the principal species used, and combined, they accounted for more than half the total consumption.

Table 2.—Veneer-log production in the Central States, 1960

State	Volume		Change from 1958
	Thousand bd. ft. ^{1/}	Percent	Percent
Indiana	12,416	21	+25
Illinois	11,760	20	+30
Kentucky	8,033	13	-34
Missouri-Iowa	15,768	27	+17
Ohio	11,135	19	+39
Total	59,112	100	+12

^{1/} International 1/4-inch rule.

More veneer logs moved in and out of the Central States Region than the slight difference of 0.7 million board feet between production and consumption would indicate. Almost 16 million board feet of veneer logs were involved in interregional shipments during the year. Incoming shipments exceeded outgoing shipments by 643,000 board feet.

Cherry, hard maple, and black walnut comprised 75 percent of the incoming shipments. Cottonwood, elm, and red oak were the principal components of the outgoing shipments, accounting for almost 47 percent of the total.

More Cooperage Timber Harvested

The 1960 production of cooperage logs and bolts amounted to over 120 million board feet, one-third more than in 1958. The value of this high-quality timber, predominantly white oak, was estimated to be almost 5 million dollars delivered at the mill.

Approximately 123 cooperage mills located within the Central States used this wood, as well as an additional 3 million board feet from states outside this territory.

Missouri was foremost in both production and consumption. Missouri forests supplied more than one-third of the total production and 48 cooperative mills in Missouri utilized one-third of the total consumption.

Trends in Pulpwood Production and Consumption

A comparison of timber growth with pulpwood production and consumption trends in the Central States for the past 6 years, indicates that our forest resources can support continued expansion of the pulpwood industry.

Over 1.8 million cords of pulpwood were harvested in the Central States from 1955 through 1960 (table 3). Production rose from a low of 192,000 cords in 1955 to almost half a million cords in 1960, an increase of 150 percent for the 6-year period.

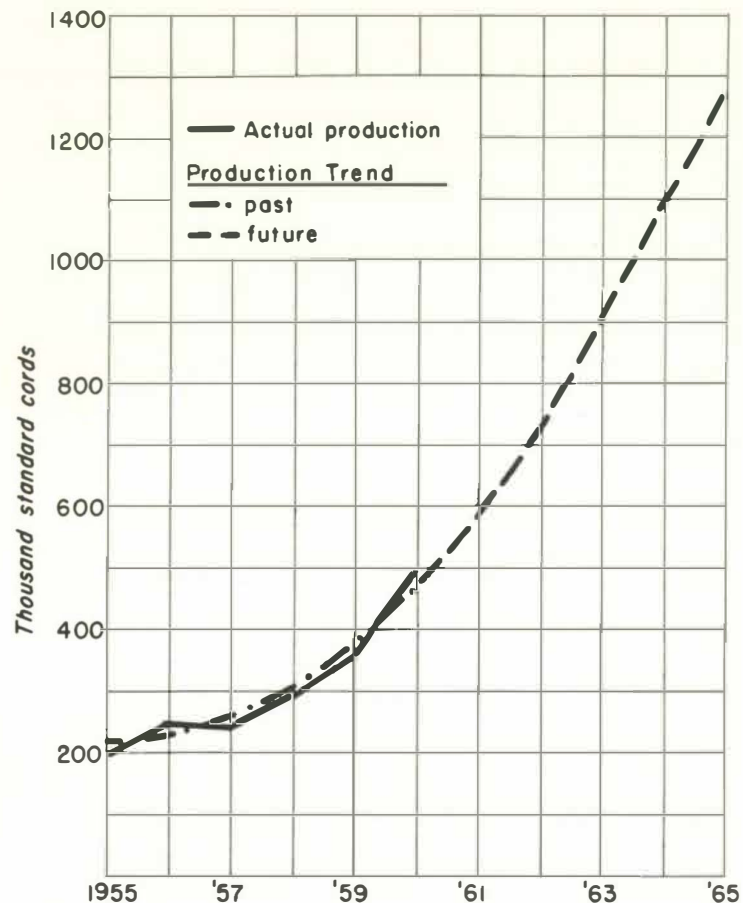
Based on the trend established during this period, it is expected that by 1965 annual pulpwood production in the Central States will increase to more than 1 million cords (fig. 30). The 1960 pulpwood cut of 491,000 cords represents approximately 3 percent of the estimated annual growth of 18.4 million cords in the Central States (45).

The projected 1965 pulpwood cut of 1.3 million cords would represent 7 percent of the annual growth. Certainly the forests here can easily

*Table 3.—Pulpwood production in the Central States, 1955-1960
(In standard cords)*

Years	Ohio	Illinois	Kentucky	Indiana	Iowa	Missouri	Total
1955	79,824	52,325	34,579	18,997	4,635	1,222	191,582
1956	95,350	60,132	53,353	16,624	14,696	5,031	245,186
1957	116,841	53,994	36,094	16,852	14,505	9,444	247,730
1958	140,515	64,234	35,121	24,618	15,079	12,017	291,584
1959	165,255	81,392	51,716	28,494	21,129	9,775	357,761
1960	214,359	107,654	76,563	55,705	23,496	13,826	491,603
Total	812,144	419,731	287,426	161,290	93,540	51,315	1,825,446

Figure 30.—
Pulpwood production trend
in the Central
States.



supply expected pulpwood production in 1965 and on into the future. However, some thought must be given to location of new mills and the expansion of wood procurement areas. Over 60 percent of the forest land in the Central States is located in Missouri and Kentucky, states that accounted for only 18 percent of the 1960 production. The forests of these two states are logical ones to provide the raw material for the expected expansion of the pulpwood industry. In the lightly forested areas where many mills are now located, more and better forestry is needed to insure adequate wood resources. Better forest management could double or even triple the present annual growth.

Timber Buying and Selling by Ohio Sawmill Operators

Markets, economic conditions, modes of transportation, equipment designs, and other factors affect the ways in which timber users obtain their log supplies and market their manufactured products. For the period 1955-58 Ohio sawmill operators purchased approximately 69 percent of

their raw material as standing timber and only 31 percent as logs. Operators producing over 1 million board feet annually depended on delivered logs for 38 percent of their production, while smaller operators obtained only about 25 percent of their timber as delivered logs.

The major market for lumber sawed by Ohio sawmill operators was the furniture and allied secondary wood-using industry. The various markets and the percent of lumber sold to each of them were as follows:

	<i>Percent</i>
Secondary wood-using industries	37
Pallet, blocking, and crating firms	28
Lumber concentrators	19
Farmers	11
Construction contractors	3
Miscellaneous	2
	100

Financial Returns Under Management

A study in the Missouri Ozarks indicates that under present market conditions, well-stocked hardwood timber stands averaging two to two and one-half 16-foot logs at maturity and under good management can earn a profit comparable to long-term bonds. However, except for the possibility of speculative returns, the same stands without management will not pay over a rotation period. Pine timber stands on the same sites and with similar stocking will normally make money whether managed or not.

The owner can afford to spend money managing some Ozark stands. Because of potentially greater yields, more can be spent on the better sites than on the poorer sites. Cumulative total costs, including interest charges, over a rotation period may range from about \$90 to \$530 per acre. Gross returns per acre may range up to \$300 on hardwood stands and up to \$1,300 on pine stands.

Financial records and field measurements of 13 small private forest tracts, more or less intensively managed, indicated these woodlands were netting anywhere from \$0.18 to \$4.07 per acre per year for their owners. The 13 sample tracts exhibited a wide range of conditions in site, timber stocking, management practice, land area, and average costs and returns.

PRODUCTS

Our search continues for new and better ways to use our native woods and for ways to increase the efficiency of harvesting and the extent of utilization of the raw product, particularly the lower grades of hardwood lumber. Here are the highlights of the year's activities in utilization research.

Wood Bricks

Three possible ways of using wood in the form of bricks or simulated bricks are being investigated.

Wood bricks of softwood, molded to form a sloped, loose tongue-and-groove on the top and bottom, are being merchandized. They are recommended for complete, load-bearing exterior walls and partition walls for summer and resort homes, garages, recreation-area structures, and other buildings and for planters, dividers, and other decorative uses. This appears to be a good use for hardwood too, so we have started a cooperative investigation of design and production of hardwood bricks and building construction principles. Hardwoods offer a wider range of colors and grain so should be more attractive than softwoods for walls and decorative uses (fig. 31).

Figure 31.—This section of building wall shows a potential use of hardwood bricks.

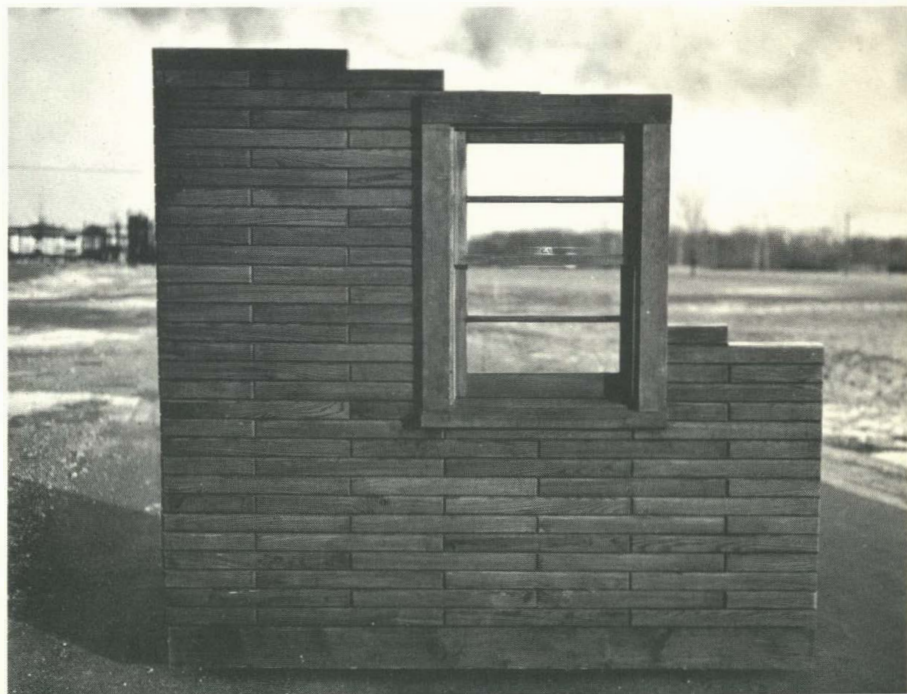




Figure 32.—Installing wood bricks is a natural for do-it-yourselfers. Many combinations of sizes and patterns can be used. Here two different sizes are being set with a mastic-type adhesive in a vertical pattern, sycamore below and soft maple above.

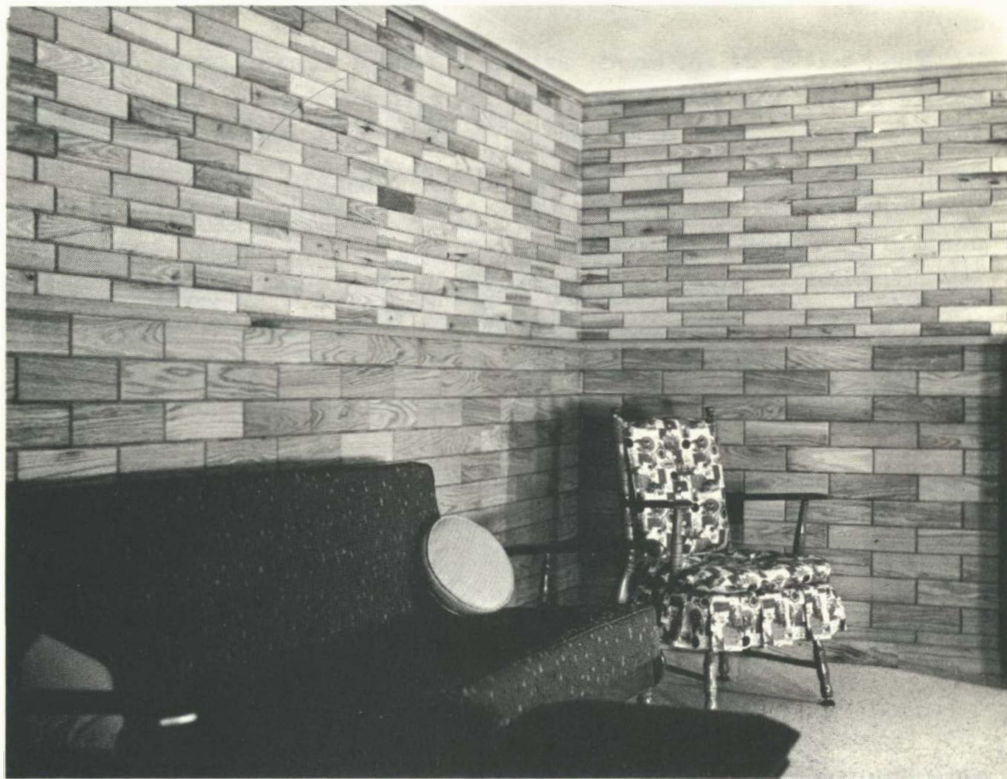


Figure 33.—Wood-brick strip paneling is as easy to apply as strip flooring. It has excellent potential as a unique, attractive, and serviceable wall covering.

Wood in small, thin pieces of brick size, or in long, thin strips cross V-grooved to give a brick appearance, makes a very attractive and unique wall covering – something quite different from the usual vertical board or plywood paneling.

We are investigating two methods of producing and applying wood "bricks" as an interior wall covering. Both methods should be of particular interest to the do-it-yourself trade and one should have commercial application.

Small pieces of wood, 2 1/4 inches wide by 9 inches long by 3/8 inch thick and 3 1/2 inches by 12 inches by 3/8 inch, with 1/4-inch-chamfered faces on all four edges, have been produced and applied to different types of vertical wall surfaces. Several different types of mastic adhesives and cements have been used (fig. 32).

These small wood bricks also offer excellent opportunities for greater utilization of wood. They can be made from No. 2 Common and poorer lumber, short boards, and waste or cull pieces in wood-industry plants. Bricks with knots or other defects can be sorted out and two grades – clear and character marked – could be merchandized.

The second type of wood-brick wall covering we are investigating is referred to, for lack of a better name, as wood-brick strip paneling (fig. 33). It is simply narrow and thin strips of wood with bevelled edges crossed at uniform spacing with a deep V-groove. The strips can be nailed, in a horizontal position, to studs or furring with the V-grooves mismatched to give a brick-wall appearance. They can be tongue-and-grooved and end-matched, like strip flooring, to permit use of random lengths in multiples of the cross V-groove spacing.

Pallets

Our investigations, started in 1959, of effect of moisture content on service life of hardwood pallets are beginning to show results. Pallets made with three combinations of green and air-dry (12 to 14 percent moisture content) red oak lumber are being compared. The combinations include: green deckboards on green stringers, air-dry deckboards on green stringers, and air-dry deckboards and stringers.

Results to date indicate that initial moisture content of the deckboards is the most important factor affecting the service life of the pal-



Figure 34.—A modified, Forest-Service-type picnic table built from No. 2 Common hickory.

lets we are studying. The ten failures in 90 pallets consisted of complete separation of a top-edge deckboard from one or more stringers due to nails either pulling through the deckboard or shearing off. No nails have pulled out of the stringers. Eighty percent of the failures occurred in pallets made with green deckboards, ten percent in each of the two combinations with dry deckboards.

Oak and Hickory Picnic Tables

Seventy-two Forest-Service-type picnic tables (fig. 34) were produced at our Wood Products Pilot Plant near Carbondale, Illinois. They were made from No. 2 Common and No. 3A Common red oak and hickory lumber (2-inch planks for tops and seats and 4- by 4-inch legs) by medium-sized-shop methods to determine production costs. We found that they can be built for about \$30. The picnic tables have been placed in National Forest and Fish and Wildlife Service recreation areas to determine suitability and service life over a period of years.

Log and Tree Grades

Good progress was made in the hardwood phase of the Forest Service National Log Grade Project. We published the "Hardwood Tree Diagramming Manual" for the project (7). It will be used to standardize diagramming in future hardwood quality studies. The standardized diagrams will provide data from individual studies that can be combined for analysis on a regional or national basis. A proposed program of research needed to round out information on hardwood log and tree grades was also prepared. Completion of these studies will contribute greatly to development of hardwood quality standards.

1961 PUBLICATIONS

- (1) Berry, Frederick H.
Sweetgum blight. The Green Leaf 2(8). Univ. of Mo. Ext. Div.,
7 pp.
(A brief general description of the disease.)
- (2) Berry, Frederick H.
Walnut anthracnose. The Green Leaf 2(3). Univ. of Mo. Ext. Div.,
7 pp.
(Describes the disease.)
- * (3) Berry, F. H., Rogers, N. F., and Dooling, O. J.
Shortleaf pine, a new host for comandra blister rust. Plant Dis.
Reporter 45(7): 576.
(Comandra blister rust was found for the first time causing damage in a shortleaf pine plantation established in 1956 and 1957 near Salem, Missouri.)
- * (4) Boyce, Stephen G., and Kaeiser, Margaret
Environmental and genetic variability in the length of fibers of
eastern cottonwood. Tappi 44(5): 363-366, illus.
(Describes the environmental and genetic variability of fiber length among 83 cottonwood trees. Shows how to identify trees with fibers inherently longer than the average for natural trees.)
- * (5) Boyce, Stephen G., and Kaeiser, Margaret
Why yellow-poplar seeds have low viability. Tech. Paper 186, 16
pp., illus.
(A study of yellow-poplar flower development, pollination, fertilization, and embryo and endosperm development shows that yellow-poplar trees produce seeds of low viability because of ineffective pollination. Reasons for this are explained and discussed.)

* Available for distribution

- * (6) Brinkman, Kenneth A., and Liming, Franklin G.
Oak and pine reproduction responds to overhead release. Jour. Forestry 59(5): 341-346, illus.
(Survival and height growth of oak and pine reproduction and planted pine were greater after 11 years in released stands in the Missouri Ozarks than in stands not released.)

- (7) Bulgrin, Erwin H.
Hardwood tree diagraming manual No. 1. 56 pp., illus.
(Sets forth the procedures, methods, guides, and definitions for hardwood log and tree diagraming to be used in all Forest Service hardwood timber quality research studies.)

- * (8) Buttery, Robert F., and Ehrenreich, John H.
Nutritive quality of little bluestem in the Missouri Ozarks. Tech. Paper 179, 9 pp., illus.
(Discusses nutrient deficiencies and seasonal changes in little bluestem that affect cattle nutrition.)

- * (9) Carmean, Willard H.
Soil survey refinements needed for accurate classification of black oak site quality in southeastern Ohio. Soil Sci. Soc. of Amer. Proc. 25(5): 394-397, illus.
(Soil-site studies of black oak in southeastern Ohio show that site index varies widely within upland soil types as they are now defined.)

- (10) Carpenter, R. D.
The national forestry program in relation to stumpage and log grades. New Methods and Tools for Improving Agricultural Marketing, Rpt. of Natl. Marketing Serv. Workshop, Biloxi, Miss., Nov. 15-17, 1960. AMS-448: 245-260.
(Summarizes the work of the National Log and Tree Grade Research Project for making log, bolt, and tree grades available to those states publishing forest products marketing information.)

- *(11) Central States Station
1960 annual report. 52 pp., illus.
(Summarizes Station's work for 1960.)

- *(12) Chapman, Arthur G.
Planting black walnut for timber. USDA Leaflet No. 487, 6 pp., illus.

(Describes recommended procedures for establishing black walnut plantations in the Central States.)

* (13) Clark, F. Bryan

Pot culture – an aid to site evaluation. Ind. Acad. Sci. Proc. 70: 234-237, illus.

(Undisturbed soil cores taken in gallon cans have been used to evaluate differences between old field and adjacent forest site in terms of seedling growth.)

* (14) Clark, F. Bryan, and Phares, Robert E.

Graded stock means greater yields for shortleaf pine. Tech. Paper 181, 5 pp., illus.

(Studies of shortleaf pine plantations in Missouri and Indiana show that use of sturdy planting stock pays off in better survival and greater timber yields.)

* (15) Clark, F. Bryan, and Seidel, Kenneth W.

Climatic injury found on planted black walnut in Kansas. Sta. Note 147, 2 pp., illus.

(A dieback resembling sunscald has been found on planted black walnut growing on strip-mined land. This climatic injury has greatly reduced the quality of many trees in the affected area.)

* (16) Clark, F. Bryan, and Seidel, Kenneth W.

Growth and quality of pruned black walnut. Tech. Paper 180, 11 pp., illus.

(Ten-year walnut pruning studies in Kansas show that as much as three-fourths of the live crown can be removed without seriously retarding growth. The possibility of sprouting, however, sets a practical limit on the amount of pruning that can be done.)

(17) Clark, F. Bryan, and Seidel, Kenneth W.

Prune young black walnut trees for high-quality wood. South. Lumberman 203(2537): 95-96.

(Semi-popular adaptation of Technical Paper 180 (see above).)

* (18) Crosby, John S.

Litter-and-duff fuel in shortleaf pine stands in southeast Missouri. Tech. Paper 178, 10 pp., illus.

(The litter-and-duff layer in Missouri Ozark shortleaf pine forests is thin, but its depth is related to basal area of pine. Because litter dries fast, its weight alone probably gives a better measure

of available forest fire fuel than the combined weight of litter and duff.)

- (19) Dalrymple, Arlo V.

Forest ranges may increase forage yields. Agr. News, Agr. Dept. Southwest Mo. State Coll. 14(3).

(Forage yield on southwest Missouri forest ranges can be greatly increased by reducing the hardwood competition, seeding, and fertilizing.)

- (20) Deitschman, Glenn H., and Pruett, Emerson W.

First-year control of weeds in forest plantings. Seventeenth Ann. Meeting, North Cent. Weed Control Conf., Proc. Dec. 12, 13, 14, 1960. Milwaukee, Wis.

(Two well-timed cultivations proved best of several mechanical and chemical methods tried for controlling weeds in new plantations.)

- (21) Dochinger, Leon S.

Twig dieback and decline of ash trees. Ind. Nursery News 20(11): 5.

(Also published in Ohio Nursery Notes 29(1): 2.)

(Describes the disease and recommends a control.)

- (22) Donley, David E.

Recent research on systemic insecticides as a tool in shade tree insect control. Sixteenth Midwestern Shade Tree Conf. Proc. pp. 71-76.

(Contains a report on controlling the mimosa webworm with systemic insecticides. The various systemic insecticides, their effectiveness, and a number of methods for their application are discussed.)

- *(23) Donley, David E., and Gibson, Lester P.

Biology of the tuliptree scale in natural regeneration of north central hardwoods. North Cent. Branch E. S. A. Proc. 16: 82-83.

(Discusses the tuliptree scale as a pest of small yellow-poplar trees. A partial list of the pest's natural enemies is included.)

- *(24) Funk, David T.

Pruning white pine. Tech. Paper 185, 13 pp., illus.

(Reviews literature on white pine pruning, presenting the consensus of most writers on the problems and questions involved.)

- *(25) Funk, David T., and Dale, Martin E.
European alder: a promising tree for strip-mine planting. Sta. Note 151, 2 pp., illus.
(Describes the merits of European alder for planting on strip-mined land.)

- *(26) Funk, David T., and Roach, Benjamin A.
Black locust – a bibliography. Misc. Release 33, 40 pp.
(Assembles all technical, English-language literature dealing with black locust published during the past 40 years.)

- *(27) Green, Alan W.
Promoting the spread of bigtooth aspen in Iowa. Sta. Note 149, 2 pp., illus.
(Tells how to enlarge the natural "pockets" of bigtooth aspen that occur in eastern Iowa.)

- *(28) Hay, C. J., and Morris, R. C.
Carpenterworm. U.S. Dept. Agr. Forest Pest Leaflet 64, 8 pp., illus.
(Describes and discusses the carpenterworm and its habits as a destroyer of hardwood timber.)

- *(29) Hay, C. John, and Myser, Willard C.
Use of p³² as an aid in biological studies of the leafhopper, *Scaphoideus luteolus*. Jour. Econ. Ent. 54(6): 1260-1261.
(A method of tagging leafhopper eggs with enough radioactivity in order to trace egg-laying habits has been developed.)

- *(30) Hill, Lawrence W.
Forest plantation development influences streamflow. Soc. Amer. Foresters Proc., 1960, pp. 168-171.
(Streamflow characteristics were altered and the general level, rate, and volume of streamflow were reduced as a result of pine plantation development on a 43.6-acre watershed near Coshocton, Ohio.)

- *(31) Hutchison, O. Keith, and McCauley, Orris D.
The small woodland owner in Ohio. Tech. Paper 183, 12 pp., illus.

(Presents results of a sample survey of small-woodland owners in Ohio; considers the owners themselves, their forest land, and their attitude toward their forest land.)

- *(32) Jensen, Chester E.

Estimating growth for large central states forest areas. Sta. Note 145, 2 pp., illus.

(Describes how to make inexpensive, but well-founded estimates of volume growth for extensive forests in the Central States.)

- (33) Jones, Thomas W.

First report of pine mortality caused by *Fomes annosus* root rot in Ohio. Plant Dis. Reporter 45(12): 980.

(Reports the first known occurrence of this disease in Ohio.)

- *(34) Jones, T. W., and Partridge, A. D.

The importance of root grafts in oak wilt spread in Missouri. Plant Dis. Reporter 45(7): 506-507.

(The frequency and pattern of root grafts between oaks in Missouri are too limited for these factors to be important avenues for spread of oak wilt.)

- (35) Kennedy, Bruce H., and Peacock, John W.

Experimental control of the mimosa webworm (*Homadaula albizziae* Clarke) with systemic insecticides. North Cent. Branch E.S.A. Proc. 16: 90-91.

(Seven organic phosphate insecticides were tested for control of the mimosa webworm by soil treatment and trunk implants.)

- *(36) Krajicek, John E.

Pin and willow oak seedlings can persist under a forest canopy. Sta. Note 146, 1 p.

(Reports a study of the ages of naturally established pin and willow oak seedlings in a bottomland stand of southeastern Missouri.)

- *(37) Krajicek, John E., Brinkman, Kenneth A., and Gingrich, Samuel F.

Crown competition - a measure of density. Forest Sci. 7(1): 35-42.

(Describes a new method for measuring stand density, based on crown characteristics of open-grown trees.)

- (38) Kucera, Clair L., and Ehrenreich, John H.

Preliminary results of burning native prairie in central Missouri. Bul. of Ecol. Soc. of Amer. 42(3): 103.

(Plant development on burned areas was 7 to 10 days earlier than on areas not burned. There was also more foliage and seedstalk production from the dominant prairie grasses on burned areas than on nonburned areas.)

- (39) McCauley, Orris D.

How to market your farm timber. The Ohio Farmer 227(4): 12, 66, illus.

(Describes steps for small-woodland owners to obtain maximum returns from timber-product sales. Presents the results of three farm woodlot sales in central Ohio as examples.)

- (40) McDermott, R. E., and Minckler, Leon S.

Shooting area management of pin oak. 26th North Amer. Wildlife and Nat. Resources. Conf. Trans. Wash. D. C., March 1961, 111-120, illus.

(Five consecutive years of dormant-season flooding of pin oak stands had no detrimental effect on the trees or on acorn production, but new reproduction on the flooded area was nearly lacking.)

- (41) McGinnies, W. G., Quigley, K. L., and McCauley, O. D.

Forest resources of southeastern Ohio. Problems in the Development and Use of the Natural Resources of Southeastern Ohio. Ohio State Univ. Nat. Resources Seminar 131-154, illus.

(Describes timber resources of southeastern Ohio and discusses the opportunities from new forest industries there.)

- (42) Marston, Richard B.

Substitution of small cans for weather bureau pans in measuring evaporation. Jour. Geophys. Research 66(2): 657-659, illus.

(Use of small containers was found to give reliable estimates of free water surface evaporation in mountainous areas where it was difficult to use standard measuring equipment.)

- *(43) Mendel, Joseph J.

Pulpwood production and consumption in the central states - 1960. Tech. Paper 182, 5 pp., illus.

(Production and consumption of pulpwood in the Central States increased for the sixth consecutive year in 1960; both reached a new high of nearly half a million standard cords.)

- (44) Merz, Robert W.
The Kaskaskia—a woodland "lab". Northeast. Logger 9(13): 14-15, 50, illus.
(Summarizes the research underway at the Kaskaskia Experimental Forest.)
- *(45) Miller, William E., Hastings, Arthur R., and Wootten, John F.
European pine shoot moth. U.S. Dept. Agr. Forest Pest Leaflet 59, 8 pp., illus.
(Describes the life history of and recommended control for this insect.)
- (46) Minckler, Leon S.
Hardwood culls - kill now or wait for markets? Northeast. Logger 10(5): 16, 35, illus.
(Hardwood cull trees should be cut and sold for pulpwood if markets are available but they should be killed if markets will not be available in 3 years or less.)
- *(47) Minckler, Leon S.
Growing bottomland hardwoods. Jour. Soil and Water Cons. 16(1): 10-12, illus.
(Overflow bottomland sites can produce high yields of quality forest products sometimes worth more than risky agricultural crops.)
- *(48) Minckler, Leon S.
Measuring light in uneven-aged hardwood stands. Tech. Paper 184, 9 pp., illus.
(Studies show that for measuring light in forestry research, repeated instantaneous measurements are a satisfactory substitute for or complement to cumulative light measurements.)
- *(49) Minckler, Leon S., and McDermott, Robert E.
Pin oak acorn production and regeneration as affected by stand density, structure and flooding. Univ. of Mo. Agr. Expt. Sta. Res. Bul. 750, 24 pp., illus.
(Four-year measurements in 25- to 35-year-old pin oak stands showed that acorn production varied greatly according to basal area and size of trees but was not affected by dormant-season flooding.)
- *(50) Minckler, Leon S., Plass, William T., and Ryker, Russell A.
Woodland management by single-tree selection: a case history. Jour. Forestry 59(4): 257-261, illus.

(Nine consecutive years of annual cuts by the single-tree-selection method using a 3-year cutting cycle in uneven-aged central hardwoods nearly eliminated the harvest-sized trees and caused composition of the reproduction to deteriorate.)

*(51) Parrish, Wayne B.

Detecting defects in wood by the attenuation of gamma rays. *Forest Sci.* 7(2): 136-143, illus.

(Describes results of studies of new and more precise methods for detecting internal decay in wood by "x-raying" it with radioisotopes.)

*(52) Partridge, Arthur D.

Growth and survival of the oak wilt fungus in oak blocks. *Forest Sci.* 7(4): 306-313, illus.

(The oak wilt fungus invaded the sapwood and heartwood of black oak and white oak blocks. Survival in these tissues was related closely to moisture content of the wood and, to a lesser degree, to time.)

*(53) Partridge, Arthur D.

Fumigants kill the oak wilt fungus in wood. *Forest Prod. Jour.* 11(1): 12-14., illus.

(Small oak bolts infected by the oak wilt fungus were sterilized by exposure to methyl bromide or chloropicrin in the laboratory, suggesting a feasible method for treating wilt-infected logs to render them safe for export.)

(54) Peters, Elroy J., Davis, Frank S., Kerr, Harold D., Fletchall, O. Hale, and Brinkman, Kenneth A.

Aerial spraying to release shortleaf pine from an oak-hickory overstory. Seventeenth Ann. Meeting North Cent. Weed Control Conf. Proc. Dec. 12, 13, 14, 1960, Milwaukee, Wis.

(One aerial application of either of two herbicides was usually enough to release planted shortleaf pine from a hardwood overstory. If competition is severe, or if grass is to be released, two applications may be necessary.)

*(55) Phares, Robert E., and Liming, Franklin G.

Development of shortleaf pine seedlings in seeded spots. *Jour. Forestry* 59(7): 515-516, illus.

(Successful direct seeding of shortleaf pine in the Missouri Ozarks may be possible if enough seed is sown to insure the initial establishment of several seedlings per spot.)

- *(56) Phares, Robert E., and Liming, Franklin G.
 Shortleaf pine direct-seeding success affected by month of seed-
 ing, release method, and weather. J our. Forestry 59(11): 804-807,
 illus.
*(Direct seeding shortleaf pine in the Missouri Ozarks was more
 successful where seeding was done in December, immediately
 following removal of overstory trees.)*
- (57) Ralston, Robert A.
 What a pulp and paper mill could mean to Missouri's forest econ-
 omy. Sixth Ann. Air and Water Pollution Conf. Proc. Engineering
 Series Bul. No. 53, Univ. of Mo. Engineering Expt. Sta., 1 p.
*(Discusses the opportunities for and desirability of establishing
 a pulp and paper mill in Missouri.)*
- *(58) Seidel, Kenneth W.
 Seeded black walnut taller than planted walnut on Kansas spoil
 banks. Sta. Note 148, 1 p.
*(Direct-seeded black walnut trees survived as well as and grew
 faster than planted trees for 10 years on Kansas spoil banks.)*
- (59) Vogel, Willis G.
 Research aids natural resources. Agr. News, Agr. Dept., South-
 west Mo. State Coll. 13(4).
*(As a part of its research program, the Forest Service has begun
 a land-use study in southwest Missouri to provide information on
 management of timber, range, watershed and wildlife habitat re-
 sources of the area.)*
- (60) Vogel, Willis G.
 Range forage resource studied. Agr. News, Agr. Dept., Southwest
 Mo. State Coll. 13(8).
*(Seeding of forage plants and fertilizing following chemical con-
 trol of woody vegetation increased forage production on experi-
 mental Ozark forest ranges in southwest Missouri.)*
- *(61) Vogel, Willis G., and Peters, Elroy J.
 Spraying, seeding, and fertilizing increase forage on Ozark forest
 ranges. Sta. Note 152, 2 pp., illus.
*(On a forest range where past overgrazing has reduced the desir-
 able native forage species, just controlling the unwanted hard-
 woods was not enough. Seeding some adapted forage species and
 applying commercial fertilizer was necessary to obtain large
 early increases in forage production.)*

(62) Whitten, R. R.

Fall spraying is effective in Dutch elm disease control. *Arborist's News* 26(10): 73-80.

(Residues from fall applications of DDT or methoxychlor sprays are effective the following year in preventing Dutch elm disease.)

*(63) Whipkey, Ronald Z.

Plywood cutoff walls for temporary weirs. *Sta. Note* 150, 2 pp., illus.

(Plywood can be used successfully for temporary cutoff walls in small watersheds where damage from debris and sediment is no problem.)

*(64) Whipkey, Ronald Z.

Water yields from small Ozark watersheds. *Jour. of Soil and Water Cons.* 16(2): 82-83, illus.

(Streamflow record analyses showed that less water per unit of area flowed from a Missouri Ozark watershed that was less than 1 square mile in area, than from two nearby watersheds 6 and 14 square miles in area.)

(65) Wollerman, E. H.

Effect of demeton on borers in black locust. *North Cent. Branch E.S.A. Proc.* 16: 91-92.

(Demeton did not control borers when 200 ml. was applied as a basal trunk wash March 28 to June 5.)

(66) Wollerman, E. H.

Locust borer reaction to radiation exposure. *North Cent. Branch E.S.A. Proc.* 16: 85-86.

(Exposure to gamma ray intensity up to 15,000 roentgens did not affect behavior, reproduction, or life span of the beetles.)

(67) Wray, Robert D.

New forest insect and disease laboratory promises help for hardwoods. *Southern Lumberman* 203(2537): 128-129, illus.

(Outlines research being conducted at the new Forest Insect and Disease Laboratories at Delaware, Ohio.)

The Central States Forest Experiment Station is headquartered at Columbus, Ohio and maintains major field offices at:

Ames, Iowa (in cooperation with Iowa State University)

Athens, Ohio (in cooperation with Ohio University)

Bedford, Indiana

Berea, Kentucky (in cooperation with Berea College)

Carbondale, Illinois (in cooperation with Southern Illinois University)

Columbia, Missouri (in cooperation with the University of Missouri)